



Industrial Hygiene Evaluation of Various Tactical Vehicles During the Vehicle Platform Demonstration in Support of the CFPI at Fort Knox, Kentucky in February 2006

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Purpose

- The purpose of this TRADOC mandated project was to evaluate the capabilities of existing vehicles on the market.
- It was not an acquisition competition.



Purpose

- For industrial hygiene the purpose of this project was to evaluate the potential hazards found in the vehicles and determine risk to the warfighter that these hazards may represent.



Background

- Industrial hygiene is a global discipline that can provide a valuable service in MANPRINT design review of military systems.
- Reviews of past tactical vehicles at Fort Knox have found serious problems that were solved early in the acquisition process.



Background

- Examples include carbon monoxide in crew compartment, asbestos, and advanced composite materials such as ceramic fibers.
- Other problem discoveries have included display icon flash rate at the brain alpha frequency (photo-epilepsy), display color and color blindness issues, materials off-gassing, and NBC system issues.



Background

Industrial Hygiene - Definition of the Profession

Industrial Hygiene is both a science and an art. It encompasses the total realm of control, including recognition and evaluation of those factors of environment emanating from the place of work which may cause illness, lack of well being or discomfort either among workers or among the community as a whole.

The Industrial Environment - its Evaluation & Control
USDHHS and NIOSH, 1973



Background

- Another directive for industrial hygiene involvement in research and development can be found in DoD Instruction 6055.5, "Industrial Hygiene and Occupational Health" that states the following on research and development:

"DoD components shall perform as appropriate to their mission and under the coordination of the Director, Defense Research and Engineering, Office of the Under Secretary of Defense (Acquisition), research and development to assess the effects and impact of specific environmental conditions, unique to the military, on personnel health and well-being, and the development of criteria or other measures to reduce or prevent their impact on health status or work performance."



Background

- The Fort Knox Industrial Hygiene Office has had a lot of experience evaluating vehicles for MANPRINT studies, industrial hygiene investigations, and for special projects. Examples of these special projects include:
- The Initial Brigade Vehicle Evaluation in January 2000
- the Infantry Carrier Vehicle (ICV) Initial Operational Test & Evaluation April 2003
- Stryker Interim Armored Vehicle Evaluation.
- In addition, IH evaluation work has been performed on the AH-64 Apache Helicopter, the M1 Abrams Main Battle Tank, the HEMMT, and M998 as a normal part of the industrial hygiene program at Fort Knox.



Methodology

- The first step was the development of a project plan. The goal of the evaluation was to test and evaluate each vehicle for health hazards as well as make recommendations. To meet this, mission design engineering review and instrumentation were used. A checklist was developed for the evaluation to insure that each vehicle received a standardized evaluation.



Methodology

- The next step was a vehicle technical document review.
- The first, “hands on” occurred at the motor pool where the vehicle was inspected and the motor pool requirements for the vehicle investigated. For example, would the current motor pool exhaust ventilation be adequate based on engine displacement?
- The first instrument measurements were made at the motor pool.
- Instrument packages were mounted in vehicles for the driving range, the live fire range, the urban warfare site and the tactical road march.



Instrumentation

- Noise measurements were performed using the Quest Electronics Model 2800 Impulse Integrating Sound Level Meter. The meter was equipped with a Model OB-300 1/3-1/1 Octave Band Filter Set. Before and after calibration was performed using a Quest Sound Calibrator Model CA-12B. Annual calibration for this system is performed by TMDE at the U.S. Army Primary Standards Laboratory Redstone Arsenal, AL.



Instrumentation

- Interior noise was measured manually under various conditions. For example, engine noise at idle and at high RPM while stationary were measured. Ventilation fan noise was measured as well as any other noise generating system. Noise measurements were made in the driver's compartment and in the passenger compartment if they were separate. Then measurements were made while riding in the vehicle at certain speeds on the same driving course.



Instrumentation

- Exterior noise was measured by collecting measurements around the vehicle at a set distance from the stationary vehicle to determine the noise level contours around the vehicle. Next, an octave band analysis was performed. Lastly, noise was measured as the vehicle drove past a stationary point.



Instrumentation

- Vibration is performed using a Bruel & Kjaer Modular Precision Sound Level Meter Type 2231 with the Human Vibration Unit Type 2522.
- Hand-Arm Segmental Vibration is performed with the Hand-Arm Segmental Vibration Set Type 4392 that consist of hand grip accelerometer block with three accelerometers Type 4374 mounted in the X, Y, and Z axis. The Type 4374 has a range of 1 to 26,000 Hz.
- Whole-Body Vibration is performed with a triaxial seat accelerometer set. This consists of a semi-rigid nitrile rubber disc containing three accelerometers Type 4322. The Type 4322 has a range of 0.1 Hz to 2 kHz.
- Annual calibration is performed by manufacture. Before and after use calibration is performed by an NIST traceable Bruel & Kjaer Exciter Type 4294. This exciter produces a reference acceleration level of 10 ms/² RMS at 159.15 Hz.



Instrument Packages

- Manual monitoring of vehicle conditions is not always possible or practical. In these cases it is necessary to use automated data collection systems. To meet the need for this project, four instrument packages were designed and fabricated. These packages can log data during the entire test run.



Instrument Packages

- Three of the instrument packages were designed for environmental conditions monitoring.
- One package was designed for human vibration monitoring.



Automated Data Acquisition

- If needed an additional instrument package could be fabricated using an IO-Tech, Inc. Logbook 360 data acquisition system. While the Solomat 4000 has a 32 data input channel capability, the Logbook 360 has nearly 256 data input channels. These include 16 high-speed digital I/O channels. The logbook can accept signals from any O.E.M. sensor. The Logbook also has GPS capability.
- These instrument packages are small and could be mounted inside the vehicle using nylon straps, bungie cords, or "C" clamps. Each installation is custom fitted to the vehicle. These instruments are internally powered by rechargeable batteries.



Data Validation

- Data validation ensures that industrial hygiene data meets the legal standards for consistent accuracy. Industrial hygiene measurements and sample results can be "LIFE CRITICAL," and involve large dollar amounts in terms of equipment and legal risk. For this reason, Federal Law, DoD Regulation, DA Regulation and guidelines require internal controls. A sample or measurement history is generated to show that sampling accuracy is at the 95% or better confidence level based on statistical analysis. All work is performed with the tenets of laboratory "prudent practice," in mind. All sample results shall have an accuracy of "precision normal" for the technique used.



Vehicle Evaluation

- A wide variety of existing off-the-shelf vehicles were evaluated. Some were tracked vehicles and some were wheeled vehicles. Some were past or current military vehicles and others were originally designed for law enforcement. Some were adaptations such as the gun box concept. All vehicles were evaluated empty and with a full combat load including crew.



Discussion and Conclusions

- Some of the interesting lessons learned include the following.
- Several vehicles had an engine compartment designed to operate under negative air pressure. This is extremely important in keeping engine exhaust out of the crew compartment.
- Carbon monoxide in one vehicle was 3.4 ppm and 6.7 ppm in another. If the exhaust system is working properly there should be zero carbon monoxide detected.
- Ventilation fan in one vehicle driver's cab increased the airborne dust load 5.9 times above the inhalable particulate standard.
- One vehicle stated that, "no more than one individual shall fire from inside the vehicle at one time."
- Noise inside one vehicle at 40 kph was 90.9 dBA



Discussion and Conclusions

- Another vehicle at max RPM had an interior noise level of 93.4 dBA
- The NBC system in one vehicle pressurized the interior 2.6 mbar above the outside barometric pressure when operating.
- One vehicle had a ventilation blower in a roof mounted turret.
- One vehicle had asbestos at the muffler and the engine compartment firewall. This vehicle also had the ventilation air intake located in the engine compartment.
- One vehicle had a gap between the cab and the rear compartment. This joint was located directly above the engine exhaust pipe. Under certain conditions exhaust gases, particulates and fumes can enter the vehicle.



The Future

- The importance of this work cannot be over stated. The future goals for the Fort Knox Industrial Hygiene Office is to continue the close working relationship with the Combat Developments Office, Directorate of Training, Doctrine and Combat Development, and the M1 Abrams Office.
- When the infantry units arrive at Fort Knox due to the BRAC the Industrial Hygiene Office will support them as well.
- The soldier deserves the best equipment possible to take into battle. The soldier should not need to worry about the hazards of the equipment while performing the mission.



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